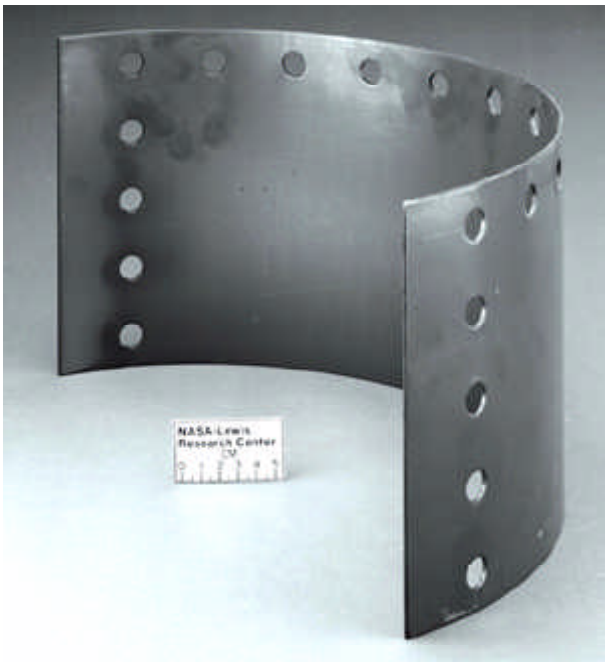
# Procedure Developed for Ballistic Impact Testing of Composite Fan Containment Concepts

The fan-containment system in a jet engine is designed to prevent a fan blade from penetrating the engine case in the event that the blade or a portion of the blade separates from the rotor during operation. Usually, these systems consist of a thick metal case that is strong enough to survive such an impact. Other systems consist of a dry aramid fabric wrapped around a relatively thin metal case. In large turbofan engines, metal-containment systems can weigh well over 300 kg, and there is a strong impetus to reduce their weight. As a result, the NASA Lewis Research Center is involved in an effort to develop polymer matrix composite (PMC) fan-containment systems to reduce the weight and cost while maintaining the high levels of safety associated with current systems. Under a Space Act Agreement with AlliedSignal Aircraft Engines, a new ballistic impact test procedure has been developed to quantitatively evaluate the performance of polymer matrix composite systems.

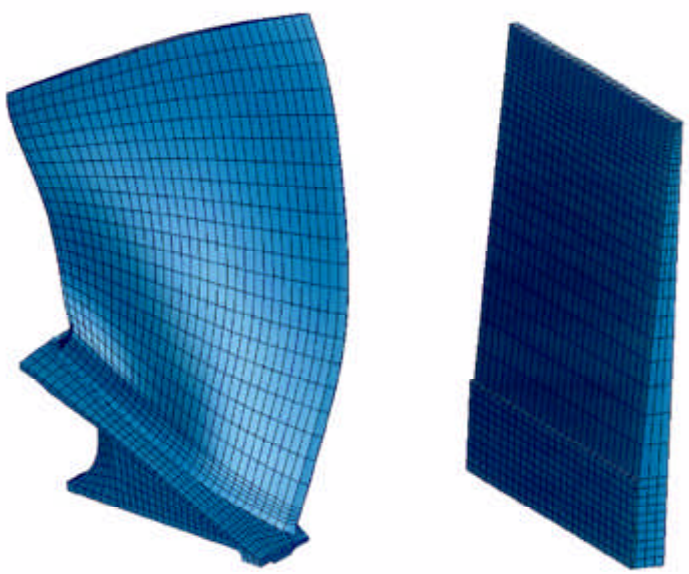



*Metal test specimen.*

The test procedure uses a curved (half-ring) specimen with an inside diameter of 38 cm (15 in.) and a width of 20.3 cm (8 in.). A metal specimen with this geometry is shown in the photo; however, typical polymer matrix composite test specimens are considerably thicker. During testing, the specimen is supported along both ends and on one edge.

The projectile used in this test is designed to simulate the most important features of a full-scale fan blade at a low cost (see the following figure). It features a relatively thick shank

section to simulate the blade attachment region, and the stiffness induced by the geometry of a twisted fan blade is approximated by tapering the thickness of the projectile from tip to shank. The projectile material has a mass of 330 g, and the projectile material is Ti-6Al-4V. In the test, the projectile is accelerated toward the specimen by NASA Lewis' 20.3-cm-diameter gas gun, which can achieve speeds of over 350 m/sec.



*Finite element models. Left: Scaled fan blade. Right: Blade-simulating projectile.*

Transient finite element analyses showed that the blade simulating projectile performs in a manner similar to that of a scaled fan blade. In a typical test, the projectile was oriented at a 45 angle from the vertical, so that the tip of the projectile would impact the specimen first. The blade then began to bend and rotate about the tip region, resulting in a secondary impact between the heavy shank section and the specimen. Analyses predicted that this secondary impact would produce more damage than the initial impact at the tip. This is consistent with experimental results.

The test procedure has been used to evaluate a number of different fan containment concepts, including two metallic systems and two composite systems. Preparations are under way for tests of more composite and hybrid metal/composite systems.

# Bibliography

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